ITN Energy Systems, Inc.
8130 Shaffer Parkway, Littleton, Colorado 80127-4107

Voice: 303 420 1141 | Fax: 303 420 1551
Email: info@itnes.com | Web: www.itnes.com

February 18, 2004

Dr. Harin Ullal, MS3212
National Center for Photovoltaics
National Renewable Energy Laboratory
1617 Cole Blvd
Golden, CO 80401
(1 soft copy to Dr. Ullal; 1 hard copy to Ms. C. Lopez)

Re: Fifth Monthly Report on Pulsed Light Annealing #NDJ-2-30630-11 Mod 6

Dear Harin,

This letter comprises the fifth monthly technical status report for "CIGS Film Fabrication by Pulsed Light Annealing of Precursor Films", which is a task added as Mod 6 to ITN's subcontract #NDJ-2-30630-11, "Plasma-Assisted Coevaporation of S and Se for Wide Band Gap Chalcopyrite Photovoltaics", under the Thin Film Partnership Program. This letter describes work performed during the reporting period of January 15, 2003 through February 14, 2004.

Goals and Approach

The primary objective of this research effort is to demonstrate the production of high-efficiency thin-film CIGS solar cells on polyimide substrates by using high-rate heating from a super-intense pulsed light source. The heating rates to be investigated (millisecond time-scale) are at least two orders of magnitude higher than those reported in previous efforts to use Rapid Thermal Processing (RTP) to convert precursor materials to CIGS films for photovoltaics. Higher heating rates may be advantageous in that (1) thermal degradation of the substrate may be avoided with fast annealing and, (2) diffusion of gallium to the back of the film, which is a major limitation encountered in other CIGS RTP work, may be dramatically reduced. Goals of the present investigation are to determine the viability and challenges of using short (<50 ms) pulses from a super intense light source to:

- Convert sputter-deposited precursor films to chalcopyrite-phase CIGS.
- Improve co-evaporated CIGS electrical properties and thereby allow the use of lower deposition temperatures while retaining device performance.
- Develop a method for CIGS film production that is well suited for production scale-up and capable of producing efficiencies that match those achieved using high-temperature co-evaporation.

An additional goal will be to determine whether high-rate heating can effectively eliminate thru-film and lateral diffusion of elements during conversion of precursor structures to produce CIGS films with high front-side gallium content.

Activities

During the current reporting period, progress was made in preparing samples for the upcoming first round of pulsed light annealing treatments. Progress was also made in fabrication of tooling for these experiments. These activities are described in more detail below.

Last month's report described several configuration changes that were made to the sputtering deposition chamber for fabrication of precursor films. During this reporting period, production of precursor films in this chamber was initiated. Precursor films consisting of a single homogenous layer containing Cu, In, Ga, and Se were deposited on both molybdenum-coated stainless steel and molybdenum-coated polyimide substrates. The run-to-run reproducibility was found to good. Figure 1 shows film composition parameter as a function of run number along with the desired "target" regions for each parameter. Tuning of the process parameters required five runs. Only minor adjustment of process parameters was needed in the remaining runs to keep the film composition within the desired range.

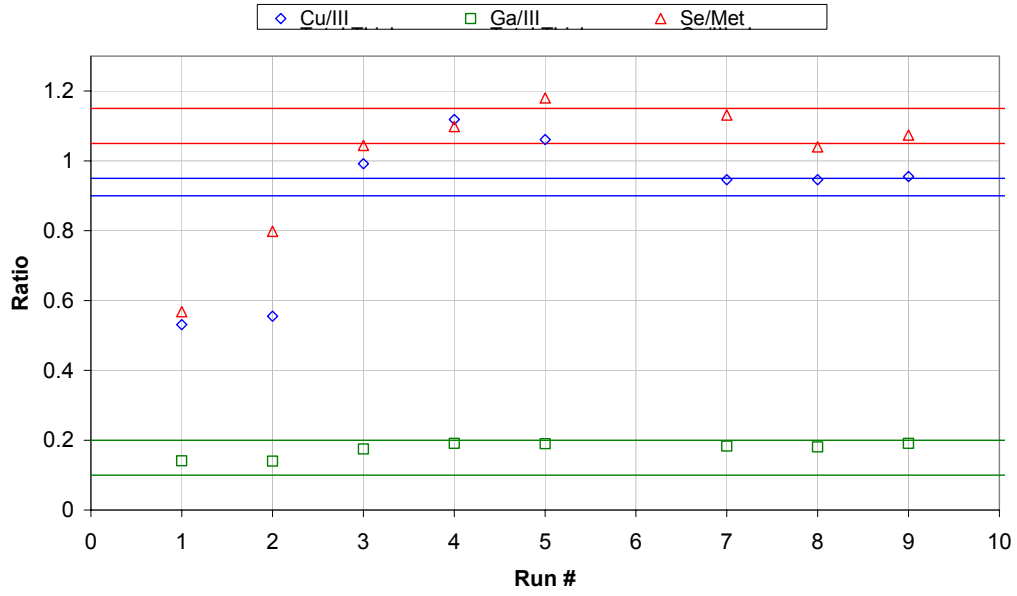

Figure 1: Film composition as measured by XRF. Cu/III = [Cu]/([In]+[Ga]), Ga/III = [Ga]/([In]+[Ga]), Se/Met = [Se]/([Cu]+[In]+[Ga]). Colored lines show the boundaries of the target zones for each parameter.

Fabrication of tooling required for the flash-lamp annealing processes was completed during this reported period except for the quartz covers. The quartz covers were fabricated, but the manufacturer did not realize that when we asked for them to be "transparent", we also wanted them to be optically clear. The surfaces of the covers therefore came with a ground-glass finish. The covers were returned to so that they could be refinished. In addition to the tooling for holding the samples during flash-lamp annealing, we also fabricated a thin black aluminum disk with a small hole in which a platinum thermo-element can be placed. This disk will be used for calibrating the pulse power in the flash lamp system.

We have scheduled the first week of March for conducting the first round of flash-lamp annealing procedures. To meet this schedule, several things must happen in the next

two weeks. Fabrication of all the required precursor films must be completed. Reflectance measurements must be performed on the samples and on the aluminum disk to be used for calibration. Temperature modeling must then be performed again to determine suitable starting parameters for the experiments.

Best Wishes,

Garth Jensen
Co-Principal Investigator
ITN Energy Systems

Cc: Ms. Carolyn Lopez; NREL contracts and business services